



Effect of Foliar Spraying of Nano ZnO on Qualitative and Physical Parameters of Tomato Grown in Polybags

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background: Tomato (*Solanum lycopersicum* L.) is the main vegetable crop extensively grown all over the globe. Tomato requires both major and micronutrients for its proper plant growth. Nano fertilizers are preferred largely due to their efficiency and environmentally friendly nature compared to conventional chemical fertilizers. Nano fertilizers are preferred largely due to their efficiency and environmentally friendly nature compared to conventional chemical fertilizers. The use of nano fertilizers is expected to maintain better soil fertility and provide greater crop yields.

Methods: A polybag experiment was conducted during Kharif, 2020-21 at Agricultural College, Palem, PJTSAU, in a completely randomized design (CRD) with fourteen treatments comprising different concentrations of nano ZnO (50, 100, 250, 500, 750, 1000, 1250, 1500, 1750, 2000, 2250 and 2500 ppm), ZnSO₄ and control.

Results: Foliar spraying of nano ZnO 1000 ppm recorded the lowest total soluble solids (4.00 °brix), highest ascorbic acid (23.71 mg 100g⁻¹), highest titrable acidity (0.48%), lowest percentage

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of total sugars (2.80%), lowest percentage of reducing sugars (2.48%), highest percentage (0.32%) of non-reducing sugars and highest value of lycopene content (6.64 mg 100g⁻¹), maximum shelf life (11.67 days) and firmness (3.05 kg cm⁻²). On 3rd, 6th and 9th day after harvest, same treatment recorded minimum physiological loss in weight (3.64%, 6.36% and 8.51%).

Keywords: *Tomato; nano ZnO; TSS; ascorbic acid; titrable acidity; total sugars; physiological loss in weight.*

1. INTRODUCTION

“Tomato (*Solanum lycopersicum* L.) is the main vegetable crop extensively grown all over the globe. Tomato requires both major and micronutrients for its proper plant growth” [11]. “Among micronutrients, Zn and B are important for plant nutrition. In India among all the micronutrients, zinc is considered as the fourth most important yield-limiting nutrient in crops. It has been postulated that zinc deficiency is likely to increase from 49- 63 percent by the year 2025 as most of the marginal soils brought under cultivation are showing the symptoms of zinc deficiency” [2]. “Zn plays an important role in growth and development as well as carbohydrates, protein metabolism and sexual fertilization of plants” [3].

“Nano fertilizers are a new generation of synthetic fertilizers which contain readily available nutrients on the nanoscale. These are preferred largely due to their efficiency and environmentally friendly nature compared to conventional chemical fertilizers. Nano fertilizers are preferred largely due to their efficiency and environmentally friendly nature compared to conventional chemical fertilizers. The use of

nano fertilizers is expected to maintain better soil fertility and provide greater crop yields. Due to the above reasons, an attempt was made to study the efficacy of foliar application of nano Zn in tomato “Effect of foliar spraying of Nano Zn on qualitative and physical parameters of tomato”.

2. MATERIALS AND METHODS

The present investigation was carried out in Kharif, 2020; at Agricultural College, Palem, Professor Jayashankar Telangana State Agricultural University. The nano particulates of zinc were prepared in a nanotechnology laboratory at the Institute of Frontier Technology, Regional Agricultural Research Station, Tirupati. High-Resolution Transmission Electron Microscopy (HR-TEM) image analysis was carried out at the Indian Institute of Technology, Roorkee. The experiment was laid out in a Completely Randomized Design (CRD) with fourteen treatments comprising different concentrations of nano Zn, ZnSO₄ and control. Each treatment was replicated thrice. The foliar application of nano boron was done at 30 and 45 DAT. The treatments details are as follows:

2.1 Treatments Details

T ₁ :	Foliar spraying with ZnSO ₄ @ 5 g L ⁻¹ (5000 ppm)
T ₂ :	Foliar spraying with nano ZnO 50 ppm (0.05 g L ⁻¹)
T ₃ :	Foliar spraying with nano ZnO 100 ppm (0.10 g L ⁻¹)
T ₄ :	Foliar spraying with nano ZnO 250 ppm (0.25 g L ⁻¹)
T ₅ :	Foliar spraying with nano ZnO 500 ppm (0.50 g L ⁻¹)
T ₆ :	Foliar spraying with nano ZnO 750 ppm (0.75 g L ⁻¹)
T ₇ :	Foliar spraying with nano ZnO 1000 ppm (1.0 g L ⁻¹)
T ₈ :	Foliar spraying with nano ZnO 1250 ppm (1.25 g L ⁻¹)
T ₉ :	Foliar spraying with nano ZnO 1500 ppm (1.50 g L ⁻¹)
T ₁₀ :	Foliar spraying with nano ZnO 1750 ppm (1.75 g L ⁻¹)
T ₁₁ :	Foliar spraying with nano ZnO 2000 ppm (2.00 g L ⁻¹)
T ₁₂ :	Foliar spraying with nano ZnO 2250 ppm (2.25 g L ⁻¹)
T ₁₃ :	Foliar spraying with nano ZnO 2500 ppm (2.50 g L ⁻¹)
T ₁₄ :	Control (Without Zinc application)

Total Soluble Solids (⁰brix): The total soluble solids of the fruits were determined with the help of an Erma hand refractometer and expressed as ⁰brix.

pH: The pH values were determined with the help of an electronic pH meter.

Ascorbic acid content (mg 100g⁻¹): Ascorbic acid was estimated by the method outlined by Ranganna.

Titrate acidity (%): Estimation of titrate acidity was carried out by using the method given by Ranganna.

Total Sugars (%): Total sugars were estimated by the method outlined by Ranganna.

Reducing Sugars (%): The reducing sugars was determined by Lane and Eyon method described by Ranganna.

Non-reducing sugars (%): The non-reducing sugar content in tomato was determined by subtracting the total sugars from the reducing sugars.

Lycopene content (mg 100g⁻¹): Milligrams of lycopene per 100 gm sample, using the formula given by R.P. Srivastava and Kumar.

Physiological loss in weight (%): "Physiological loss in weight (PLW) was determined by recording the initial weight of the fruits on the day of initiating experiment and subsequently at three days intervals. The loss of weight in grams and in relation to initial weight was calculated and expressed in percentage.

$$\text{PLW (\%)} = \frac{(\text{Initial weight} - \text{Final weight})}{\text{Initial weight}} \times 100$$

Shelf Life (Days): "Shelf life of the fruits was determined by recording the number of days the fruits remained in good condition in storage. The stage where in more than 50 percent of the stored fruits became unfit for consumption was considered as end of shelf life in that particular treatment and expressed as mean number of days.

Firmness (kg cm⁻²): "Penetrometer was used to record the firmness of fruits and direct readings were obtained in terms of kg cm⁻². The sample fruits were subjected to penetrometer by

pressing near the center of the fruit and direct reading on the scale was recorded.

3. RESULTS AND DISCUSSION

Total soluble solids (⁰brix): Data present in Table 1 indicates that, a decreasing trend of total soluble solids was found with the increased level of nano ZnO up to 1000 ppm. Among the treatments, T₇ (nano ZnO 1000 ppm) recorded the lowest total soluble solids (4.00 ⁰brix), which was on par with T₆ (nano ZnO 750 ppm) (4.10 ⁰brix), while it was significantly high (5.40 ⁰brix) in T₁₃ (nano ZnO 2500 ppm). It might be due to its involvement in synthesis of tryptophan that is a precursor of auxin, auxins help in mobilization of carbohydrate from source to sink which intern increases TSS.

Ascorbic acid (mg 100g⁻¹): It is evident from the data that, highest ascorbic acid (23.71 mg 100g⁻¹) was registered with foliar spraying of nano ZnO 1000 ppm, which was on par with T₆, T₅, and T₈ (Table 1). Increased ascorbic acid with the application of zinc might be due to its role as a component of many proteins, particularly carbonic anhydrase and carboxylase that led to enhanced vitamin C content of the fruit.

The minimum ascorbic acid content was recorded in T₁₃ which was on par with T₁₂ and T₁₁. This could be linked to phytotoxicity effect of elements at higher concentrations.

These results are in conformity with Quincy et al. [4] in tomato and Prasad et al. [5] in tomato.

Titrate acidity (%): The data (Table 1) enunciated on titrate acidity as influenced by the foliar spraying of nano zinc and ZnSO₄ revealed that, among the treatments, T₇ (nano ZnO 1000 ppm) recorded the highest titrate acidity (0.48%), which was on par with T₆. The increased titrate acidity content in tomato fruits with the application of zinc might be due to its role in carbohydrate metabolism and synthesis of related enzymes. While it was significantly low in both T₁₂ (nano ZnO 2250 ppm) (0.33%) and T₁₃ (nano ZnO 2500 ppm) (0.33%) which was on par with T₁₁ (nano ZnO 2000 ppm) (0.34%).

Total sugars (%), Reducing sugars (%): Lowest percentage of total sugars (2.80%), reducing sugars (2.48%) was registered in T₇ (nano ZnO 1000 ppm) which was on par with T₆, T₅, T₈ and T₁. The highest percentage of total sugars (3.33%), reducing sugars (3.22%) was

recorded with T₁₃ (nano ZnO 2500 ppm) (Table 1).

“Reason for decreasing the total sugars and reducing sugars is, it is a component of molecular structure of enzymes carbonic anhydrase which is involved in photosynthesis and causes an increase in the level of soluble sugars” [6]. “Application of micronutrients may increase the mobilization of carbohydrates from source to sink. An association of zinc with synthesis of auxins in plants played a vital role in increasing enzymatic activities. This leads the bio-chemical reactions involving the conversion of complex food i.e. starch into simple sugars” Henare et al. [7] Mishra et al. [8] and Ramiar and Karami, [9].

The increasing trend of total sugars was found in the present study with the increased level of nano ZnO from nano ZnO 1250 ppm (T₈) to nano ZnO 2500 ppm (T₁₃).

Non - reducing sugars (%): The results present in (Table 1) indicates that, foliar spraying of nano ZnO and ZnSO₄ with varied doses recorded significant influence on non-reducing sugars (%). Among the treatments, T₇ (nano ZnO 1000 ppm) recorded the highest percentage (0.32%) of non-reducing sugars, while it was significantly low in T₁₃ (nano ZnO 2500 ppm) (0.11%).

Lycopene content (mg 100g⁻¹): The observations from Table 1 confirm that T₇ (nano ZnO 1000 ppm) recorded the highest value of lycopene content (6.64 mg 100g⁻¹) which was on par with T₆, T₈ and T₉. The minimum lycopene content (5.83 mg 100g⁻¹) was recorded in T₁₃. These results are in accordance with the findings of Salam et al. [10] in tomatoes and Mishra et al. [8] in tomatoes.

High concentrations of nano ZnO (T₁₁, T₁₂ and T₁₃) recorded less ascorbic acid, titrable acidity, Non – reducing sugars, lycopene content and high total soluble solids, total sugars, reducing sugars than ZnSO₄ and control. This could be associated with the phytotoxicity effect of this element at high concentrations.

Physiological loss in weight (%): From the data (Table 2) pertaining to percentage of physiological loss in weight at 3rd, 6th, 9th and 12th day after harvest, as influenced by the foliar application of nano ZnO and ZnSO₄ it is

observed that the percent of physiological loss in weight values showed an increasing trend from 3rd to 12th day after harvest during storage.

On 3rd, 6th and 9th day after harvest, T₇ (nano ZnO 1000 ppm) recorded minimum physiological loss in weight (3.64%, 6.36% and 8.51%) which was on par with T₆, while it was significantly maximum (4.24%) in T₁₃ (nano ZnO 2500 ppm). On 9th day after harvest T₁₁, T₁₂ and T₁₃ treatments showed the end of shelf life.

On 12th day after harvest all treatments showed the end of shelf life. The results are supported by Saba and Amini [11] in pomegranate.

Shelf life (days): It is evident from the data (Table 2) that, among the treatments, T₇ (nano ZnO 1000 ppm) recorded highest shelf life (11.67 days) which was on par with T₆ (nano ZnO 750 ppm) (11.50 days), T₅ (nano ZnO 500 ppm) (11.33 days) and T₈ (nano ZnO 1250 ppm) (11.03 days). The minimum shelf life was recorded with T₁₃ (nano ZnO 2500 ppm) (9.00 days).

Firmness (kg cm⁻²): Firmness is important tomato character needed for long distance transport. The higher the firmness is, the less is the ratio of water to the flesh. As a result, the fruit will be more tolerant to transportation damages. The observations from Table 2 confirm that T₇ (nano ZnO 1000 ppm) recorded the highest value of fruit firmness (3.05 kg cm⁻²) which was on par with T₆ (nano ZnO 750 ppm) (3.00 kg cm⁻²). The minimum firmness (1.90 kg cm⁻²) was recorded in T₁₃ (nano ZnO 2500 ppm). The reason for increasing the firmness with the application of Zn might be due to it stimulates carbohydrates, proteins, DNA and RNA formation. Zinc plays an important role in synthesis of cell walls which helps to withstand prolonged periods without desiccation of middle lamella, as a result, improves resistance power against microbial activities, thereby decreasing the physiological loss in weight, increasing the shelf life and firmness Mishra et al. [8] Ullah et al. [12] Zinc also helps to overcome heat stress as a result the surface skin of fruit will not be distorted easily as a result improves the post-harvest storage quality [5]. These results were found to be in line with those reported by Li et al. [13] in apple, Xu et al. [14] in carrot and Prasad et al. [5] in tomato [15].

Table 1. Effect of foliar spraying of nano ZnO on physiological loss in TSS, pH, ascorbic acid, titrable acidity, total sugars, reducing sugars non- reducing sugars and lycopene content of tomato grown in polybags

Treatments	TSS (°brix)	pH	Ascorbic acid (mg 100g ⁻¹)	Titrable acidity (%)	Total sugars (%)	Reducing sugars (%)	Non reducing sugars (%)	Lycopene content (mg 100g ⁻¹)
T ₁	4.50	4.64	20.98	0.40	2.92	2.69	0.23	6.35
T ₂	5.00	4.65	21.50	0.38	3.21	3.06	0.15	6.00
T ₃	4.90	4.49	21.50	0.38	3.12	2.95	0.17	6.05
T ₄	4.80	4.43	21.80	0.39	3.11	2.93	0.18	6.07
T ₅	4.30	4.67	23.08	0.45	2.89	2.60	0.29	6.52
T ₆	4.10	4.57	23.40	0.46	2.84	2.54	0.30	6.54
T ₇	4.00	4.69	23.71	0.48	2.80	2.48	0.32	6.64
T ₈	4.40	4.54	22.92	0.43	2.90	2.64	0.26	6.50
T ₉	4.60	4.60	22.50	0.42	2.99	2.78	0.21	6.50
T ₁₀	4.70	4.58	22.08	0.42	3.10	2.92	0.18	6.12
T ₁₁	5.30	4.44	20.00	0.34	3.28	3.17	0.11	5.90
T ₁₂	5.30	4.46	19.60	0.33	3.30	3.19	0.11	5.85
T ₁₃	5.40	4.48	19.30	0.33	3.33	3.22	0.11	5.83
T ₁₄	5.20	4.64	20.50	0.36	3.21	3.07	0.14	6.01
SEm±	0.12	0.07	0.36	0.01	0.05	0.05	0.004	0.07
CD (P=0.05)	0.34	NS	1.03	0.02	0.15	0.13	0.01	0.21

Table 2. Effect of foliar spraying of nano ZnO on physiological loss in weight (%) at 3rd, 6th, 9th and 12th day after harvesting, shelf life and firmness of tomato grown in polybags

Treatments	Physiological loss in weight (%)				Shelf life (days)	Firmness (kg cm ⁻²)
	3 rd day after harvesting	6 th day after harvesting	9 th day after harvesting	12 th day after harvesting		
T ₁	3.89	7.02	10.05	*	10.63	2.70
T ₂	4.11	7.75	10.82	*	10.03	2.22
T ₃	4.06	7.58	10.54	*	10.23	2.32
T ₄	4.02	7.27	10.12	*	10.43	2.41
T ₅	3.74	6.70	9.05	*	11.33	2.91
T ₆	3.71	6.59	8.84	*	11.50	3.00
T ₇	3.64	6.36	8.51	*	11.67	3.05
T ₈	3.82	6.78	9.13	*	11.03	2.86
T ₉	3.92	7.02	9.51	*	10.60	2.70
T ₁₀	3.94	7.12	9.84	*	10.33	2.51
T ₁₁	4.19	8.18	*	*	9.23	2.00
T ₁₂	4.22	8.43	*	*	9.13	1.99
T ₁₃	4.24	8.57	*	*	9.00	1.90
T ₁₄	4.15	7.95	*	*	9.50	2.14
SEm±	0.05	0.11	0.16		0.35	0.05
CD (P=0.05)	0.13	0.33	0.46		1.02	0.13

4. CONCLUSION

Foliar spraying of nano ZnO exhibited a significant effect on quality and physical parameters of tomato. Among the different concentrations, nano ZnO 1000 ppm recorded the lowest total soluble solids (4.00 °brix), highest ascorbic acid (23.71 mg 100g⁻¹), highest titrable acidity (0.48%), lowest percentage of total sugars (2.80%), lowest percentage of reducing sugars (2.48%), highest percentage (0.32%) of non-reducing sugars and highest value of

lycopene content (6.64 mg 100g⁻¹), maximum shelf life (11.67 days) and firmness (3.05 kg cm⁻²). On 3rd, 6th and 9th day after harvest, same treatment recorded minimum physiological loss in weight (3.64%, 6.36% and 8.51%). On 12th day after harvest, all treatments showed the end of shelf life.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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